GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. A-3245 DATE 5-7-82

Project Director: S. F. KANEY ~~School~~/Lab SEL

Sponsor: USAF, Warner Robins ALC, Robins AFB, GA 31098

Type Agreement: Delivery Order 0005 under BOA F09603-82-G-3367

Award Period: From 4-15-82 To ~~10-15-82~~ 12/31/83 (Performance) 10-15-82 (Reports)

Sponsor Amount: $10,000 Contracted through:

Cost Sharing: None GTRI/~~GIT~~

Title: Bare Base Chemical Toilet Circuit Card Assemblies

ADMINISTRATIVE DATA OCA Contact Don Hastey

1) Sponsor Technical Contact:

Anthony M. White or
Keith DAMMANN
WR-ALC/MMIRDA
(912) 926-6194 (White)
" " -2809 (Dammann)

2) Sponsor Admin/Contractual Matters:

T. Bryant
ONR-IRR
Campus
881-4213

Defense Priority Rating: DO-C9e under DMS Reg 1 Security Classification: N/A

RESTRICTIONS

See Attached DOD Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval — Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.) See below

Equipment: Title vests with Government; however, none proposed

COMMENTS:

Per Diem/Travel costs cannot exceed limits of referenced joint Travel Regulations.

COPIES TO:

~~Administrative Coordinator~~ Admin Network
Research Property Management
Accounting
Procurement/EES Supply Services
FORM OCA 4:781

Research Security Services
~~Reports Coordinator (OCA)~~
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 8/29/83

Project Title: Bare Base Chemical Toilet Circuit Cord Assemblies

Project No: A-3245

Project Director: S. F. Kaney

Sponsor: USAF, Warner Robins ALC, Robins AFB, GA 31098

Effective Termination Date: 10/15/82

Clearance of Accounting Charges: 10/15/82

Grant/Contract Closeout Actions Remaining:

- [X] Final Invoice and Closing Documents
- [ ] Final Fiscal Report
- [X] Final Report of Inventions (Patent Questionnaire attached for Project Director
- [X] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Assigned to: SEL (School/Laboratory)

COPIES TO:

RAN Administrative Coordinator	Research Security Services	EES Public Relations (2)
Research Property Management	Reports Coordinator (OCA)	Computer Input
Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other S. F. Kaney

FORM OCA 10:781

A-3245

ENGINEERING ANALYSIS
OF
BARE BASE CHEMICAL TOILET CIRCUIT CARD ASSEMBLIES

P/N 103717 and P/N 103718

Prepared for
Warner Robins Air Logistics Center
MMIRDA
Warner Robins, Ga.

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Ga. 30332

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I. PURPOSE

The purpose of this report is to provide a functional description of two circuit card assemblies P/N 103717 (12 second timer) and 103718 (Logic Control) and to provide the necessary engineering data for procuring the circuit boards.

The following information is provided in this report:

- A complete parts list of both boards
- A complete manufacturing specification for each board and each individual component
- Drawings and manufacturing techniques for each board
- Soldering and plating diagrams for each board
- Trouble shooting procedure for damaged circuit board
- Suggested improvements

II. PROJECT ACTIVITIES AND PROCEDURES

The basic project objective was to reverse-engineer two circuit card assemblies used in the electronic control box of the Bare Base Chemical Toilet. After receiving one sample of each of the circuit card assemblies, engineering analysis of each of the cards began. This engineering analysis included a detailed description of the circuit cards' functions, complete component identification, including military specifications and available vendors, descriptions of the mechanical layout of each card, and all other data necessary to document the circuit card assemblies in order to provide a complete procurement package. This information was collected and organized and forms the basis of this report.

Also, as a secondary effort, damaged circuit cards were repaired and returned to the sponsor to increase the available working inventory.

III. COMPONENT SPECIFICATIONS

Component specifications for each board (see Figures 1 and 2) are listed with the requested Military Specifications numbers and component locations. The capacitors, resistors, and transistors are standard components and can be purchased from various electronic distributors (e.g., Hamilton-Avenet, Schweber, Arrow, Marshall, etc.). The printed circuit contacts on both boards are special purpose board-to-board contacts and are manufactured by Elco Connector Division.* Board No. 103717 (12 second timer) has a DPDT (double-pole double-throw), 10 amp contact, relay that can be procured from Airpax Corporation.** Board No. 103718 (Logic Control) has two relays that can be procured from General Electric.***

Circuit schematics for each board are also provided (see Figures 3 and 4) to show the functions and relations of the electronic components found on each board. A detailed circuit functional analysis of each board is provided in Section VIII.

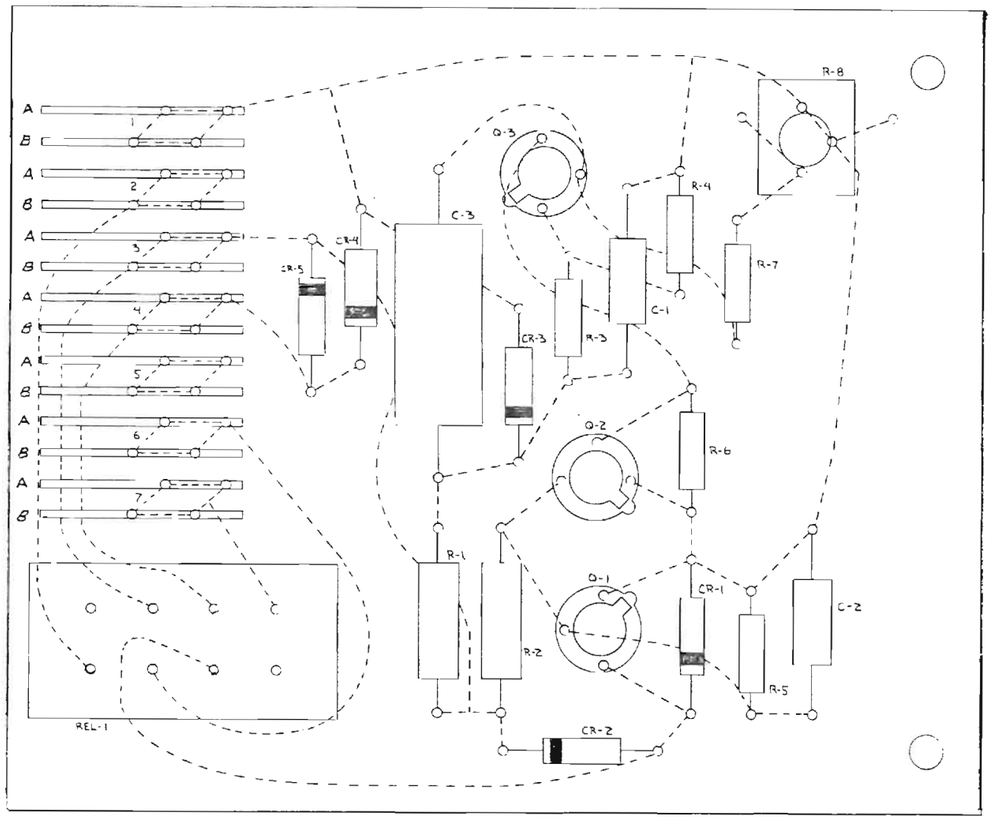
* ELCO, Electronic Connector Division
Huntingdon Industrial Park
Huntingdon, PA 16652
(814) 643-0700

** Airpax Corporation, North American Philips Co.
Frederick Division
Husky Park, Frederick, MD 21701
(301) 663-5141

*** General Electric
Electronic Component Sales Department
1835 Savoy Dr.
Atlanta, GA
(404) 458-8401

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

NOTE: * AS PER MIL-R-39008
** AS PER MIL-C-39003/1B
*** ALSO TO MIL-R-MS757/23 AND 6106



COMPONENTS SIDE

FIGURE #1

COMPONENT SIDE VIEW
P/N 103717

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.
Q-1	1		TRANSISTOR	2N2222	JAN2N2222A	
Q-2	1		TRANSISTOR	2N2222	JAN2N2222A	
Q-3	1		TRANSISTOR	2N2907A	JAN2N2907A	
CR-1	1		DIODE	1N979A	JAN1N979A	
CR-2	1		DIODE	1N649	JAN1N649	
CR-3	1		DIODE	1N757A	JAN1N757A	
CR-4	1		DIODE	1N4946	JAN1N4946	
CR-5	1		DIODE	1N649	JAN1N649	
R-1	1		RESISTOR	3300Ω 1/2 Watt	*RCR07G332KM	
R-2	1		RESISTOR	3300Ω 1/2 Watt	*RCR07G332KM	
R-3	1		RESISTOR	2700Ω 1/4 Watt	*RCR05G272KM	
R-4	1		RESISTOR	2700Ω 1/4 Watt	*RCR05G272KM	
R-5	1		RESISTOR	2700Ω 1/4 Watt	*RCR05G272KM	
R-6	1		RESISTOR	10KΩ 1/4 Watt	*RCR05G103KM	
R-7	1		RESISTOR	220KΩ 1/4 Watt	*RCR05G224KM	
R-8	1		POTENTIOMETER	200KΩ POT 24PT1	*RJR32F201M	
C-1	1		CAPACITOR	1 μF	**CSR13G105ML	
C-2	1		CAPACITOR	1 μF	**CSR13G105ML	
C-3	1		CAPACITOR	47 μF	**CSR13E476MM	
REL-1	1		RELAY	807A013BC1	*** TO MIL-R-5757	
1-7B	7		P.C. CONTACT	5203-147		
1-7A	7		P.C CONTACT	5203-137		

PARTS LIST

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125 ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

CONT NO
CHG NO
DWN P. WARREN 6 3 82
ENGR
CHK
PROD
APVD
APVD

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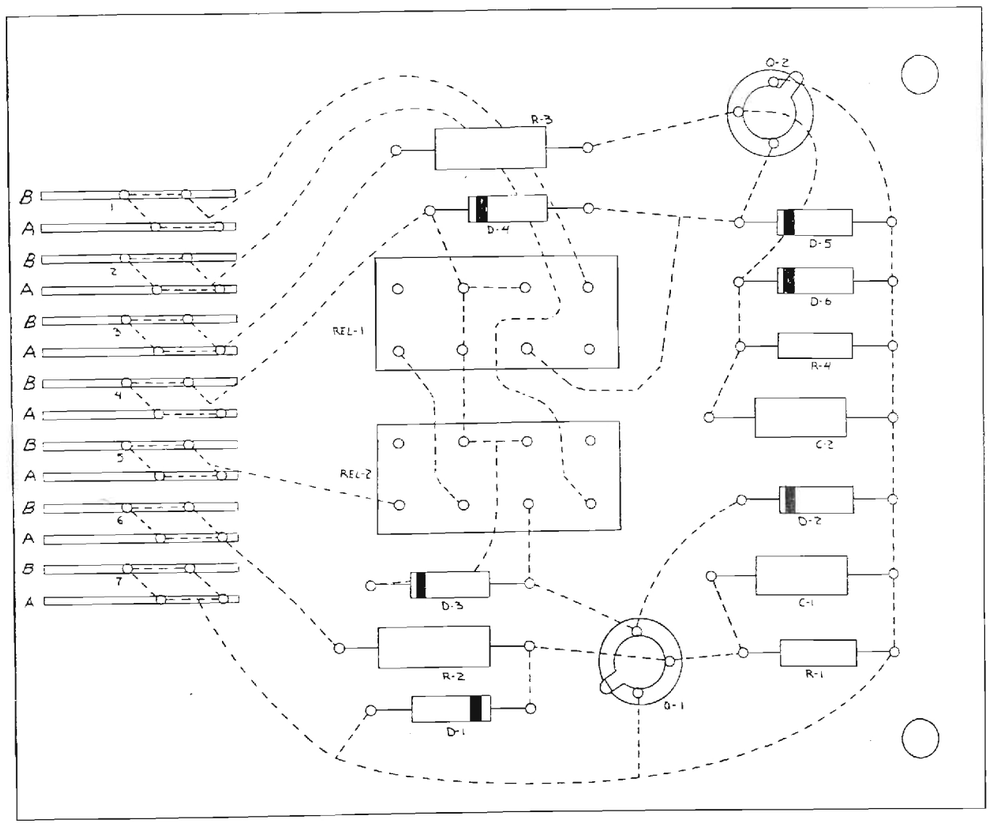
COMPONENT SIDE
CIRCUIT CARD ASSEMBLY
P/N 103717

SIZE D | CODE IDENT NO. 07101 | DRAWING NO A-3245-004
SCALE / | FIGURE #1 | SHEET -

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

NOTE: * AS PER MIL-R-39008
** AS PER MIL-C-39003/1B



COMPONENTS SIDE

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.
D-1	1		DIODE	IN4833	JANIN483B	
D-2	1		DIODE	IN979A	JANIN979A	
D-3	1		DIODE	IN649	JANIN649	
D-4	1		DIODE	IN649	JANIN649	
D-5	1		DIODE	IN979A	JANIN979A	
D-6	1		DIODE	IN483B	JANIN483B	
R-1	1		RESISTOR	470Ω 1/4 Watt	*RCR05G471KM	
R-2	1		RESISTOR	5.6KΩ 1/2 Watt	*RCR07G562KM	
R-3	1		RESISTOR	5.6KΩ 1/2 Watt	*RCR07G563KM	
R-4	1		RESISTOR	470Ω 1/4 Watt	*RCR05G471KM	
C-1	1		CAPACITOR	1μF	**CSR13G105KL	
C-2	1		CAPACITOR	1μF	**CSR13G105ML	
REL-1	1		RELAY	GE 3SAV2109AZ	TO MIL-R 5757/9	
REL-2	1		RELAY	GE 3SAV2109AZ	TO MIL-R-5757/9	
Q-1	1		TRANSISTOR	2N2222A	JAN2N2222A	
Q-2	1		TRANSISTOR	2N2222A	JAN 2N2222A	
1-7B	7		P.C. CONTACT	5203-147		
1-7A	7		P.C. CONTACT	5203-137		

PARTS LIST

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

CONT NO
CHG NO
DWN P. WARREN 5-27-82
ENGR
CHK
PROD
APVD
APVD

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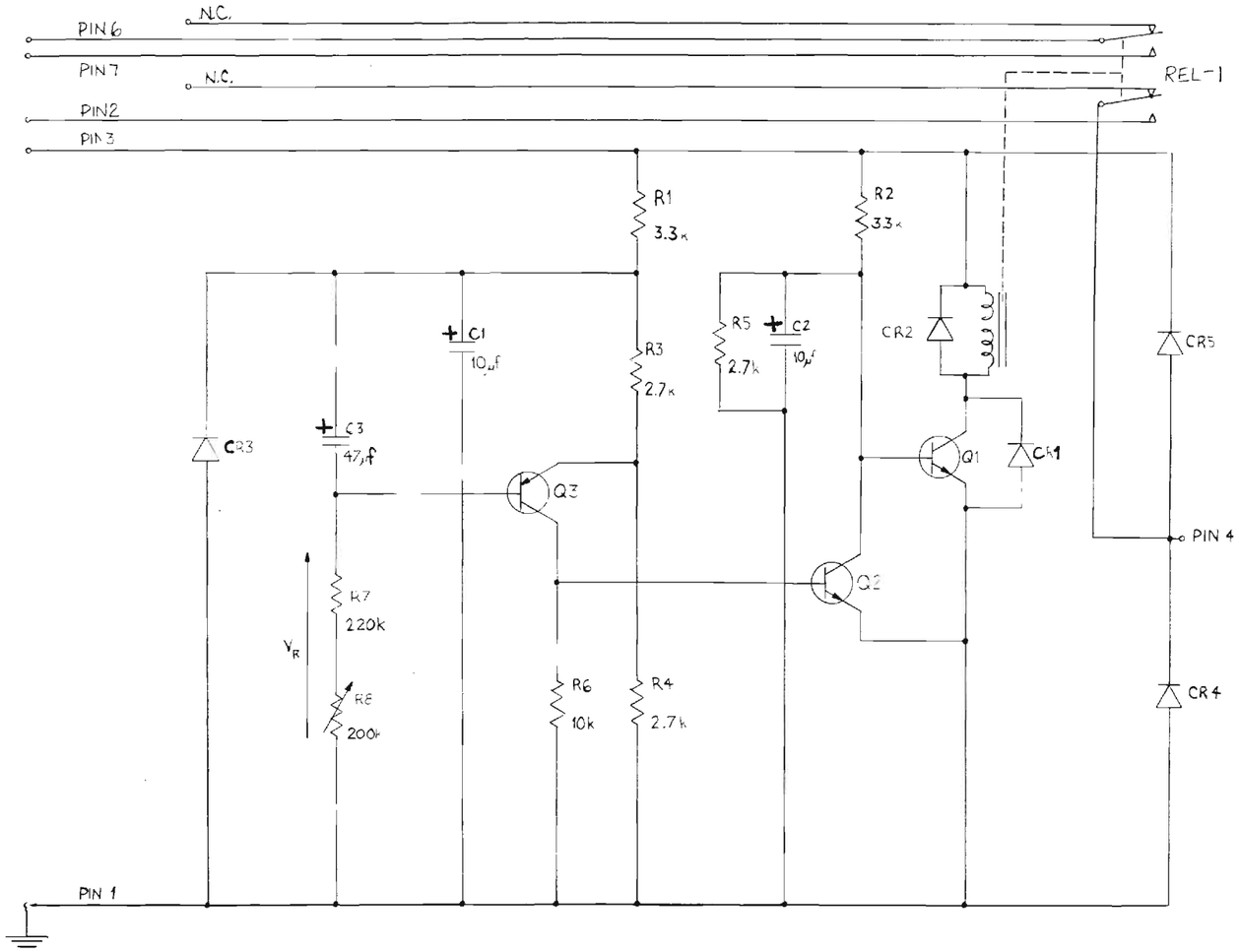
COMPONENT SIDE
CIRCUIT CARD ASSEMBLY
P/N 103718

SIZE D | CODE IDENT NO. 07101 | DRAWING NO. A-3245-002
SCALE / | FIGURE #2 | SHEET

FIGURE #2

COMPONENT SIDE VIEW

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED



SCHEMATIC

NOTE: RELAYS SHOWN IN DE-ENERGIZED POSITION

FIGURE #3

SCHEMATIC
P/N 103717

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

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ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA

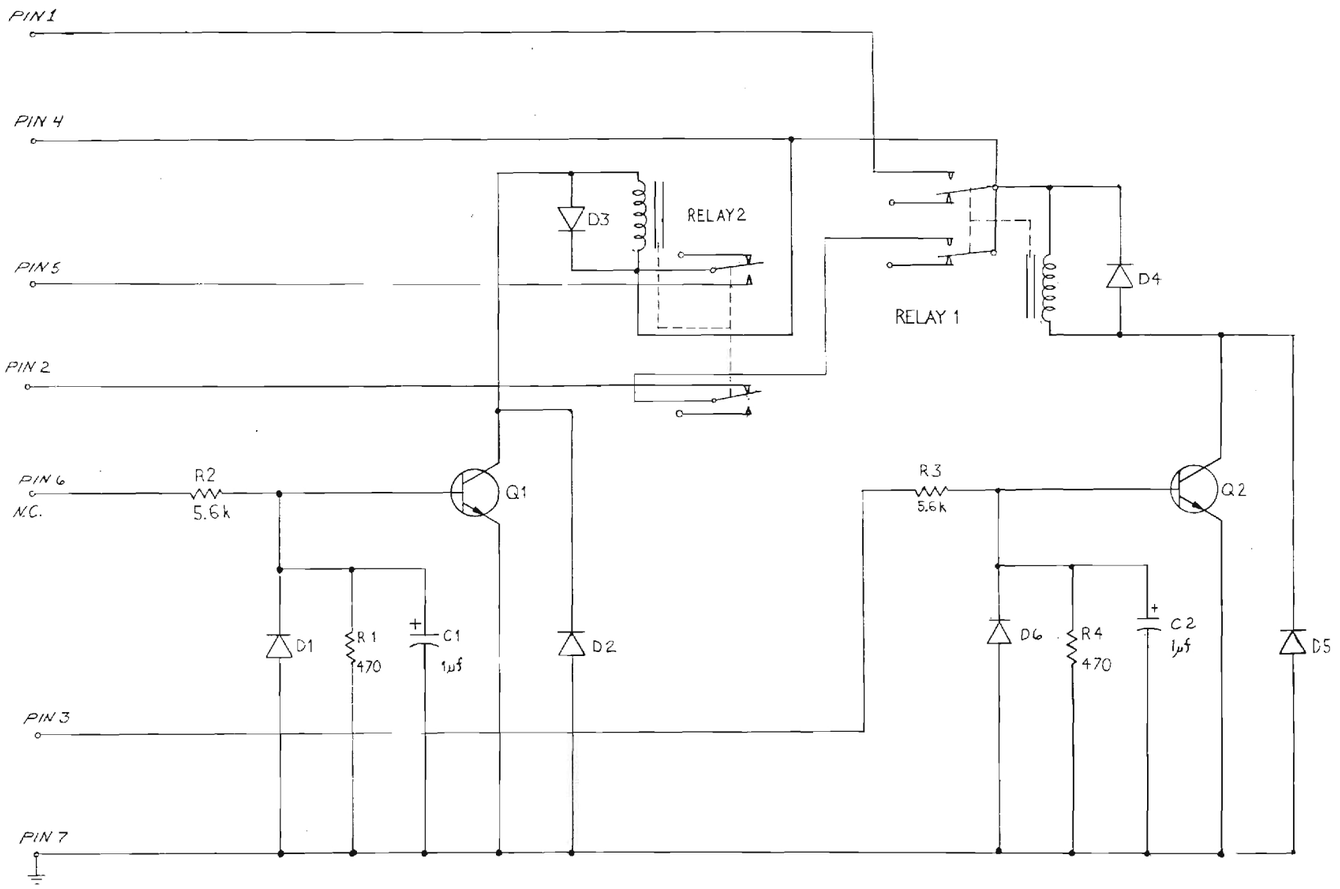
SCHEMATIC
CIRCUIT CARD P/N 103717
12 SECOND TIMER

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-005

SCALE / FIGURE #3 SHEET

8	7	6	5	4	3	2	1

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED



SCHEMATIC

NOTE: RELAYS SHOWN
IN DE-ENERGIZED POSITION

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0° 30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES
EXCEPT AS NOTED
BREAK SHARP EDGES
AND CORNERS .010 MAX
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ATLANTA, GEORGIA

SCHEMATIC
CIRCUIT CARD P/N 103718
LOGIC CONTROL

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-005

SCALE / FIGURE #4 SHEET

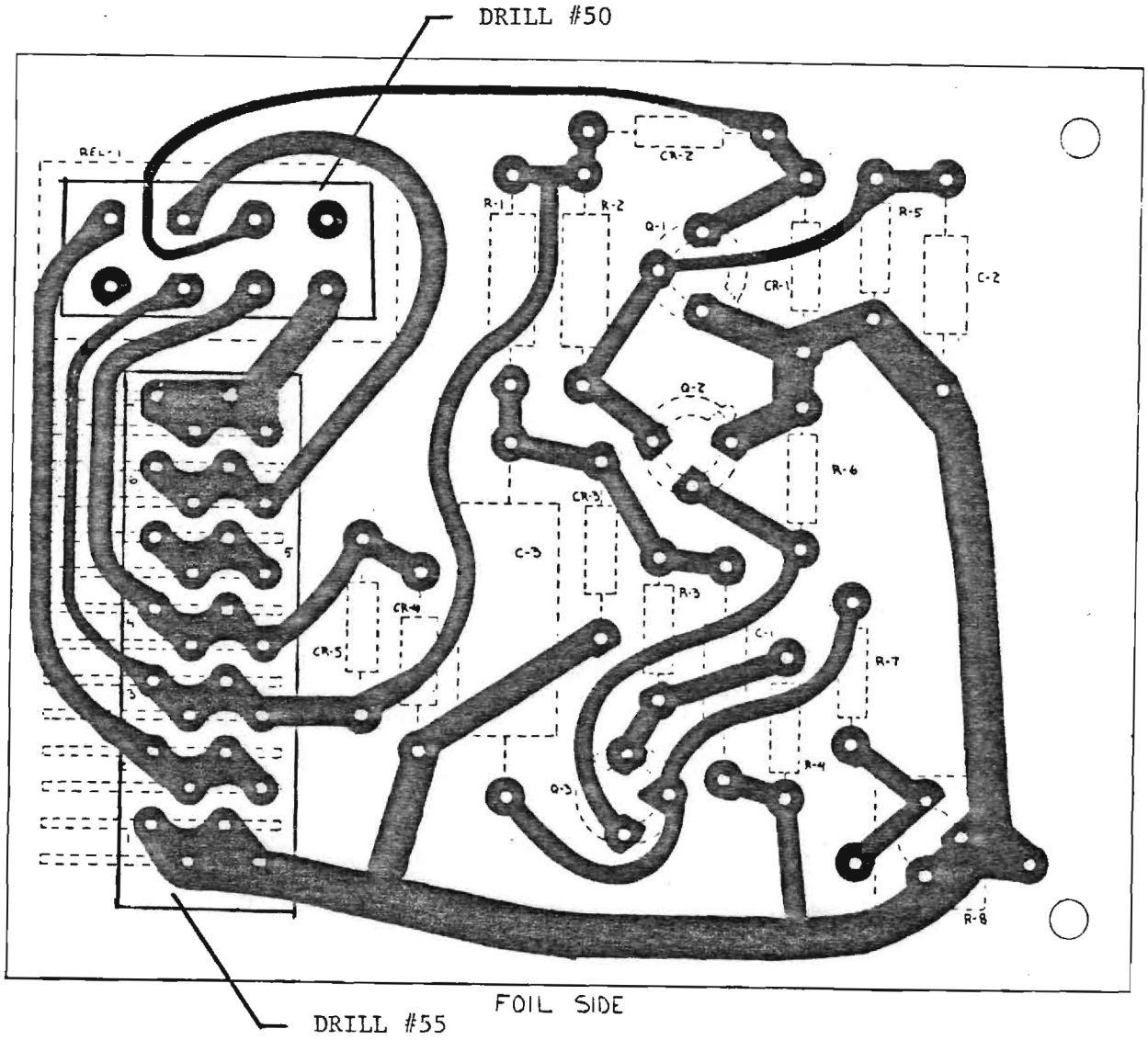
FIGURE #4

SCHEMATIC
P/N 103718

IV. BOARD SPECIFICATIONS

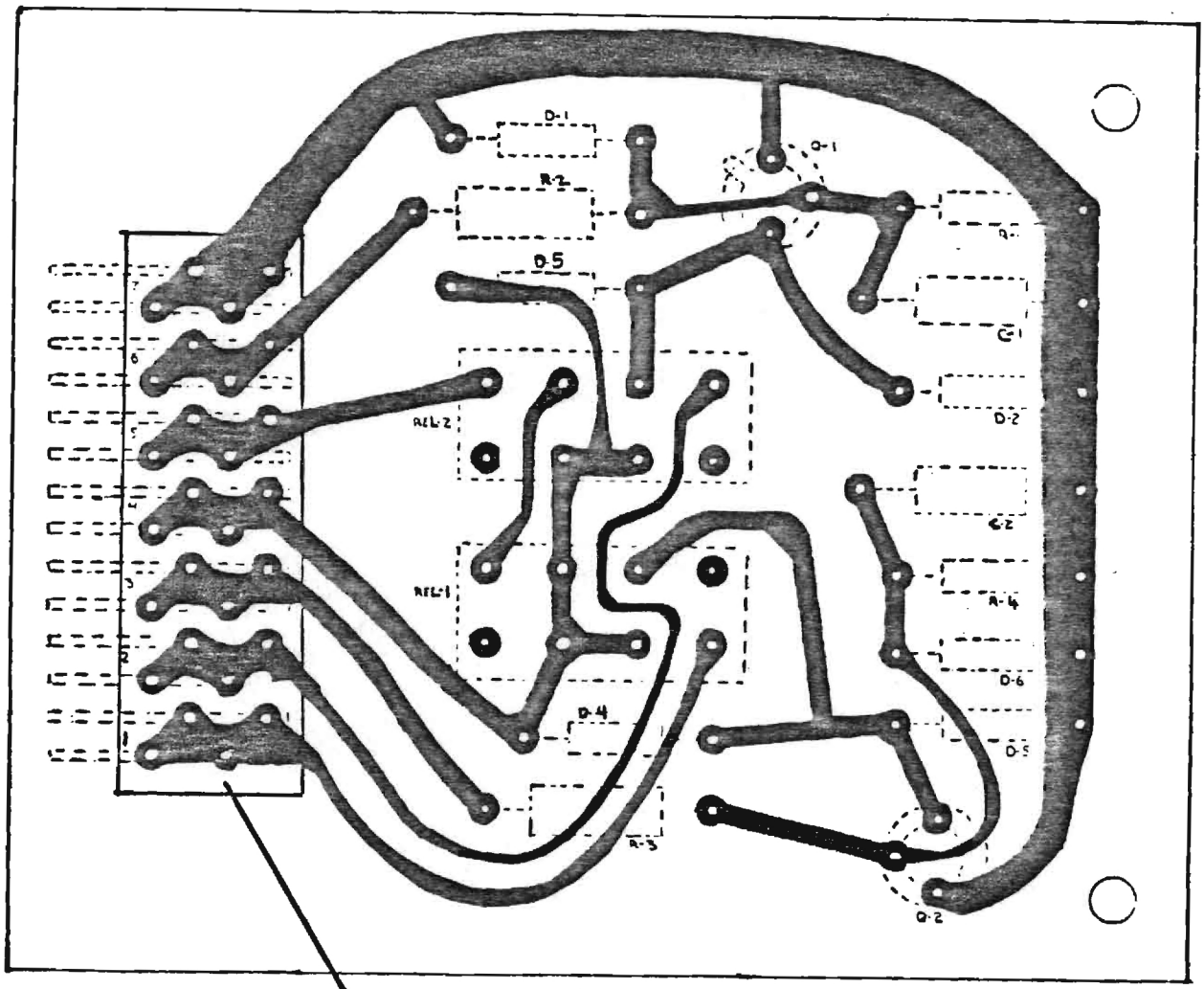
Board No. 103717 (12 second timer) has dimensions of 2 9/16" x 3 1/8" x 1/16" thick. It should have 2 oz. copper on one side. There are 74 non-plated thru holes. Hole sizes and location are shown on Figure 5, Hole Drilling Chart. There are 28 #55 drill holes and 46 #66 drill holes. The board material meets MIL-P-13949.

Board No. 103718 (Logic Control) has dimensions of 2 9/16" x 3 1/8" x 1/16" thick. It should have 2 oz. copper on one side. There are 90 non-plated thru holes. Hole sizes and location are shown on Figure 6, Hole Drilling Chart. There are 8 #50 drill holes, 28 #55 drill holes and 54 #66 drill holes. The board material meets MIL-P-13949. Figure 7 and 8 are mechanical drawings revealing the appropriate dimensions and tooling holes for P/N 103717 and P/N 103718 respectively.



ALL OTHERS DRILL #66

FIGURE #5 DRILL CHART FOR 103717

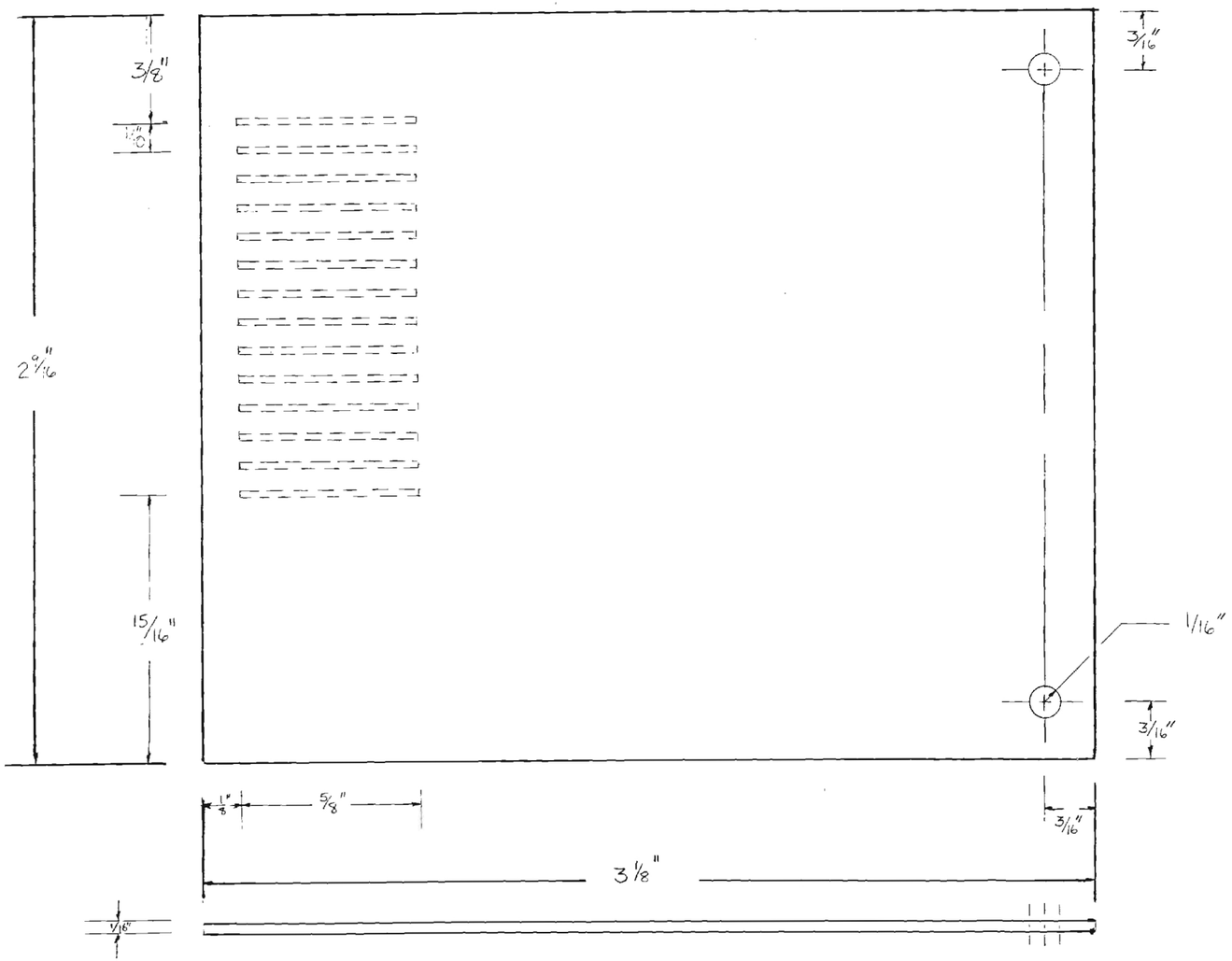


ALL OTHERS DRILL #66

FIGURE #6 DRILL CHART FOR 103718

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

TOP VIEW



SIDE VIEW

FIGURE #7

MECHANICAL DRAWING
P/N 103717

MATERIAL SPECIFICATIONS
BOARD MATERIAL MEETS
MIL-P-13949

TOLERANCES
± .020 IN. ON ALL DIMENSIONS

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

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APVD

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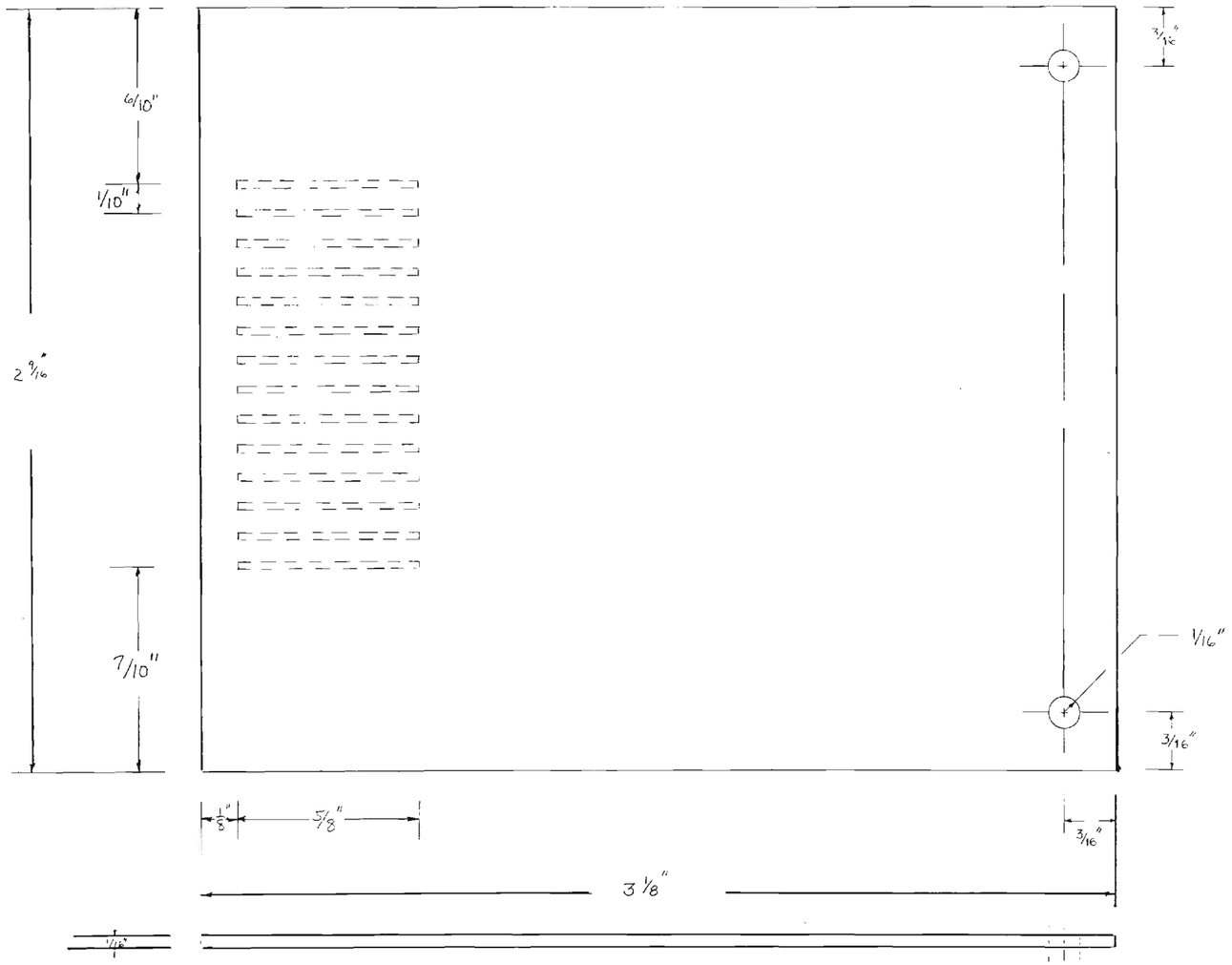
MECHANICAL DRAWING
CIRCUIT CARD P/N 103717
12 SECOND TIMER

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-008

8	7	6	5	4	3	2	1

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

TOP VIEW



SIDE VIEW

FIGURE #8

MECHANICAL DRAWING
P/N 103718

MATERIAL SPECIFICATIONS
BOARD MATERIAL MEETS
MIL-P-13949.

TOLERANCES
± .020 IN. ON ALL DIMENSIONS

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0° 30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

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MECHANICAL DRAWING
CIRCUIT CARD P/N 103718
LOGIC CONTROL

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-007

SCALE / FIGURE #8 SHEET

V. MANUFACTURING TECHNIQUES

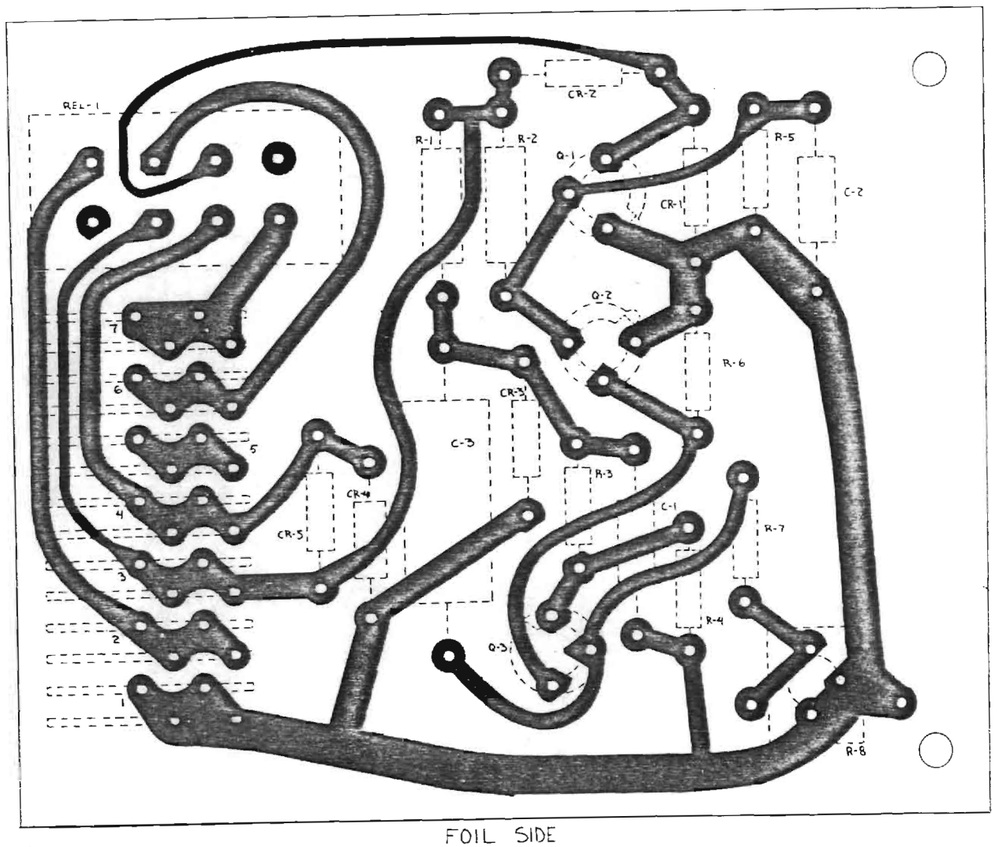
Artwork is provided which must be reduced 4 to 1 to obtain the proper negative size. Foil Side views show artwork layout (See Figures 9 and 10).

The boards shall be processed in such a manner as to be uniform in quality and be free from defects in excess of those allowed in MIL-P-55110C.

Components are to be mounted according to Figures 1 and 2.

Solder masks for each board are provided in Figures 11 and 12. The actual blue lines of all the figures referenced in this document are provided. The solder mask blue lines are scaled 4 to 1.

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED



FOIL SIDE

FIGURE #9

FOIL SIDE VIEW
P/N 103717

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.
			PARTS LIST			

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES EXCEPT AS NOTED
BREAK SHARP EDGES AND CORNERS .010 MAX
FINISH

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DWN P. WARREN 6-3-82
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CHK
PROD
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APVD

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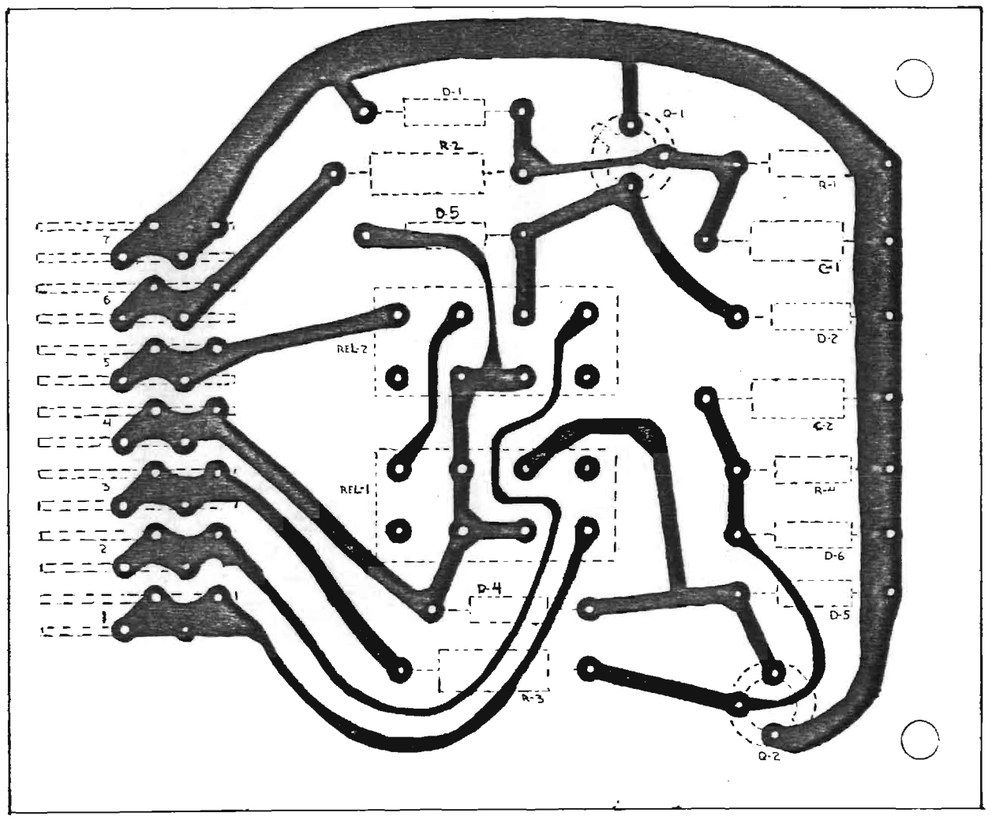
FOIL SIDE
CIRCUIT CARD ASSEMBLY
P/N 103717

SIZE	CODE IDENT NO.	DRAWING NO
D	07101	A-3245-006

SCALE / FIGURE # 9 SHEET 1 OF 1

REV

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED



FOIL SIDE

FIGURE #10

FOIL SIDE VIEW
P/N 103718

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES
EXCEPT AS NOTED
BREAK SHARP EDGES
AND CORNERS .010 MAX
FINISH

CONT NO
CHG NO
DWN PPW 5-26-82
ENGR
CHK
PROD
APVD
APVD

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OF THE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA GEORGIA

FOIL SIDE
CIRCUIT CARD ASSEMBLY
P/N 103718

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-001

SCALE / FIGURE #10 SHEET 1 of 1

D C B A

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

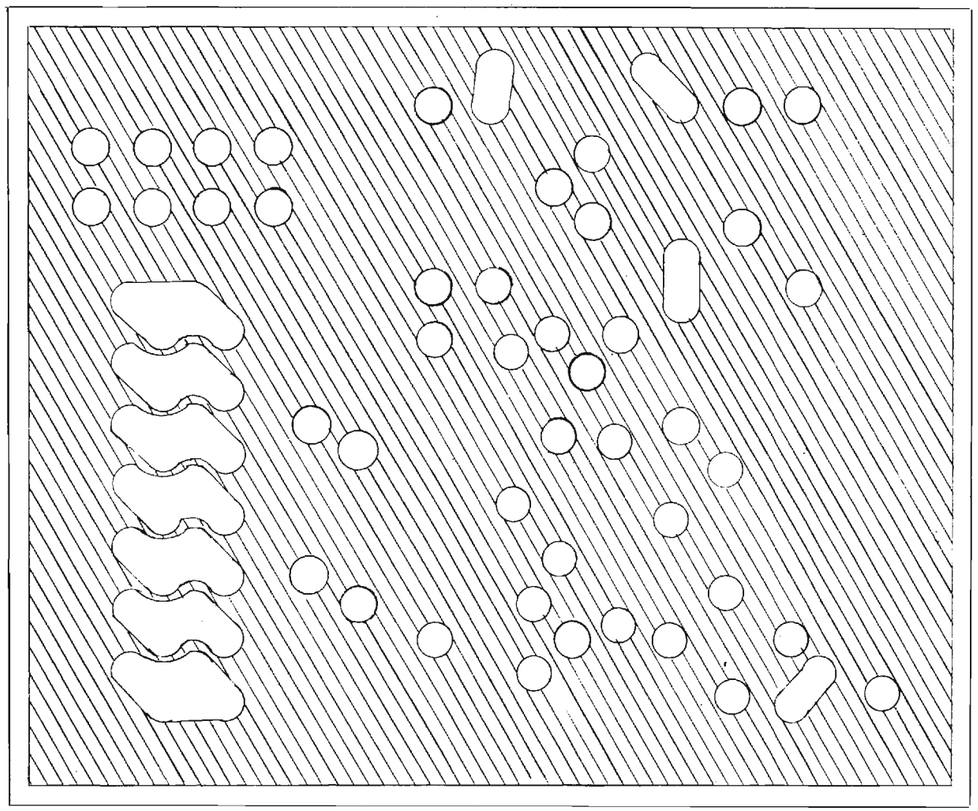

FIGURE #11

SOLDER MASK
P/N 103717

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0° 30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES
EXCEPT AS NOTED
BREAK SHARP EDGES
AND CORNERS .010 MAX
FINISH

CONT NO
CHG NO
DWN MR H.
ENGR
CHK
PROD
APVD
APVD

GTEES ENGINEERING EXPERIMENT STATION
OF THE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

SOLDER MASK
CIRCUIT CARD P/N 103717
12 SECOND TIMER

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-009

SCALE 4/1 FIGURE #11 SHEET

D C B A

APPLICATION			REVISIONS				
QTY REQD	NEXT ASSY	USED ON	ZONE	SYM	DESCRIPTION	DATE	APPROVED

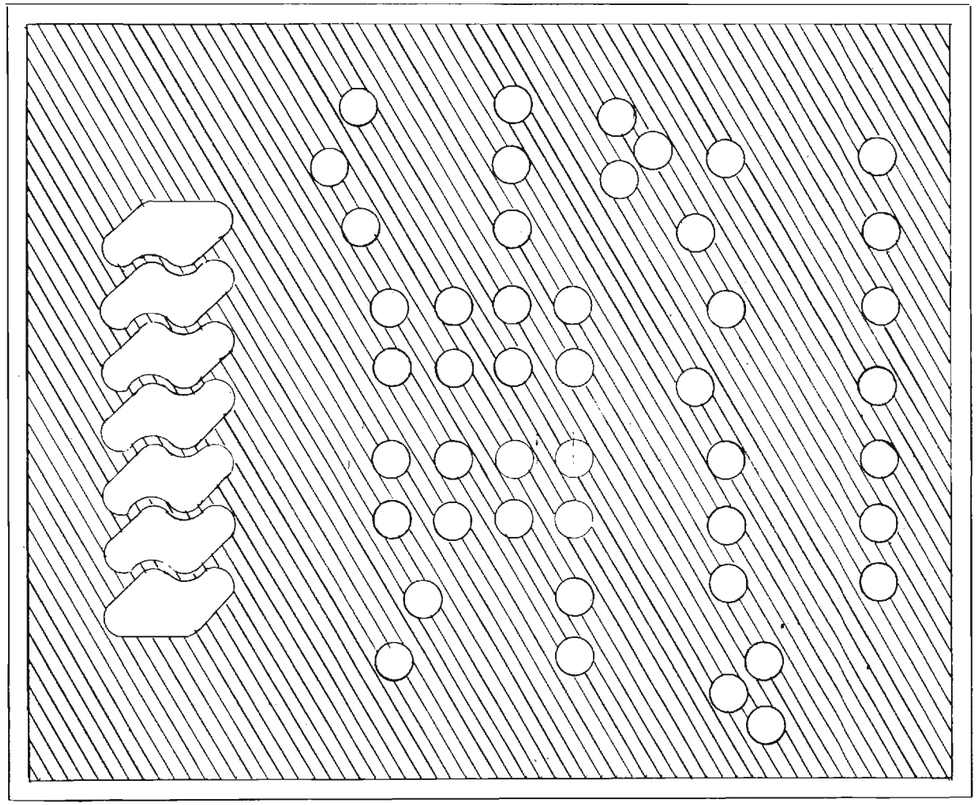

FIGURE #12

SOLDER MASK
P/N 103718

ITEM OR FIND NO.	QTY REQD		NOMENCLATURE OR DESCRIPTION	MATL SPEC AND SIZE OR COMPONENT VALUE	IDENTIFYING OR PART NO.	CODE IDENT.

PARTS LIST

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
TOLERANCES
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±
FRACTIONS ± ANGLES ± 0°30'
MAX SURFACE ROUGHNESS 125
ALL MACHINED SURFACES
EXCEPT AS NOTED
BREAK SHARP EDGES
AND CORNERS .010 MAX
FINISH

CONT NO
CHG NO
DWN MR H.
ENGR
CHK
PROD
APVD
APVD

GTRI EES ENGINEERING EXPERIMENT STATION OF THE GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GEORGIA

SOLDER MASK
CIRCUIT CARD P/N 103718
LOGIC CONTROL

SIZE	CODE IDENT NO.	DRAWING NO.
D	07101	A-3245-010

SCALE 4/1 FIGURE #12 SHEET

D C B A

VI. TROUBLESHOOTING PROCEDURES

1. Visual Inspection of printed circuit boards and components.

The suspect board should be removed from the motherboard and visually inspected for open traces, imperfect solder joints, broken leads, or overheated components. Specifically, on P/N 103717 (12 second timer), board failure has been attributed to open traces from pin 4 to the relay and from the relay to pin 2. Simple continuity checks can be performed to verify most of these problems.

2. Component Testing.

Suspect components on the board should be removed and out-of-circuit tests performed to reveal component breakdown. These out-of-circuit tests are described in Section VII. If a particular component continues to break down after replacement, then external factors to the board can be causing the malfunctions.

VII. COMPONENT TESTING

This section describes out-of-circuit ohmmeter tests that can be performed on resistors, capacitors, diodes, and transistors to determine faulty components (NOTE: resistors, capacitors, diodes, and other axial lead components require only one lead to be removed from the circuit). Since the basis of these tests are to measure resistance, it is important not to touch the ohmmeter leads. There is no danger of shock, but the body resistance as a parallel path will affect the accuracy of the reading.

1. Resistors

Connect the resistance being measured between the ohmmeter leads. The ohmmeter should read the appropriate resistance specified by its color code within a given tolerance. The construction of resistors is such that the trouble they usually develop is an open, with infinitely high ohms.

2. Capacitors

When using an ohmmeter to check capacitors of greater than about 0.01 μfd, the highest ohms range is preferable. Connect the ohmmeter leads across the capacitor. For a good capacitor, the meter pointer moves quickly toward the low-resistance side of the scale and then recedes toward infinity (charging action). The reading when the pointer stops moving is the insulation resistance of the capacitor, which is normally very high. If the ohmmeter reading immediately goes practically to zero and stays there, the capacitor is short-circuited. If the capacitor shows no charging action, but just reads very high resistance, it may be open. Some precautions must be remembered, however, since very high resistance is a normal condition for capacitors. Reverse the ohmmeter leads to discharge the capacitor, and check it again. If the capacitor shows charging, but the final resistance reading is appreciably less than normal, the capacitor is leaky. Such capacitors are particularly troublesome in high-resistance circuits. When checking electrolytics, reverse the ohmmeter leads and take the higher of the two readings.

3. Diodes

A diode should have at least 100 times more resistance in the reverse directions compared with the forward resistance. Just connect the ohmmeter across the diode in one polarity, and then reverse the leads for the opposite polarity. A silicon diode has practically infinite resistance in the reverse direction. When the resistance is very high in both directions, the diode is open. When the resistance is very low in both directions, the diode is shorted.

4. Transistors

Check the resistance between base and collector and reverse the leads. Do the same for base and emitter. You should get a very high reading when the junction is reverse-biased and a very low reading when the junction is forward-biased. These tests really check each transistor junction as a diode. The actual reading in ohms depends upon your ohmmeter, the range selected, and the type of transistor. For conclusive tests, make a comparison with another transistor of the same type that is known to be good. It is helpful to realize that the reverse resistance of a silicon junction is usually infinite. Obtaining proper results of this test is a necessary but not sufficient condition for an operable standard transistor. Loss of gain and impaired breakdown voltages will not be apparent.

VIII. CIRCUIT CARD FUNCTIONAL ANALYSIS

1. The functional block diagram for P/N 103717 (see Figure 13) shows general circuit operation of the 12 second timer that is used to control the power source which activates the flush value. The circuit schematic shown in Figure 3 reveals further detail. When a potential is applied across pins 1 and 3 by a momentary pushbutton switch, transistor Q1 conducts immediately energizing REL-1 which latches Pin 6 to 7 and Pin 2 to 4. These connections are assumed to activate the flushing mechanism.

The capacitor C1 and resistors R1, R3, R4 provide a debouncing network for the actuating switch, these components have approximately a 20 millisecond time constant. Capacitor C2 and resistor R5 prevent chatter in the relay and have a time constant of approximately 15 milliseconds.

The resistors R1, R3, and R4 form a voltage divider to select 62% of the applied voltage and apply it to the network containing resistors R7 and R8 and capacitor C3. These resistors also provide a threshold of 31% of the applied voltage to the emitter of transistor Q3. Capacitor C3 charges toward the 62% voltage with a time constant adjustable between 10.3 and 20.7 seconds. When capacitor C3 has charged sufficiently, it causes transistor Q3 to conduct, as the remaining voltage across resistors R7 and R8 drops. Resistor R8 may be adjusted to cause the interval to be exactly the desired time delay (usually 12 seconds). When transistor Q3 starts conducting, base current is provided to Q2 causing conduction. Transistor Q2's conduction causes the base potential of transistor Q1 to be drawn low which cuts transistor Q1 off. When transistor Q1 stops conducting relay REL-1 de-energizes opening the connections between Pins 6 and 7 and Pins 2 and 4 which deactivates the flushing mechanism. Capacitor C3 recycles through resistor R3 and the base-emitter junction of transistor Q3 permitting a new delay cycle to start about 0.1 second after the previous one.

Diode CR2 conducts the coil current until it decays to prevent damaging voltage kickbacks to Q1. Diode CR1 provides added protection against reverse transients for Q1.

Diodes CR4 and CR5 serve apparently as anti-reverse polarity protectors. External fusing will be blown by the conduction of these diodes if an error in power polarity is made.

Diode CR3 serves to protect the electrolytic capacitors C3 and C1 from damage from reverse polarity.

2. The functional block diagram for P/N 30718 (see Figure 14) shows the general operation of the control logic board. More specific information can be obtained from the schematic (see Figure 4) and the following description of component function.

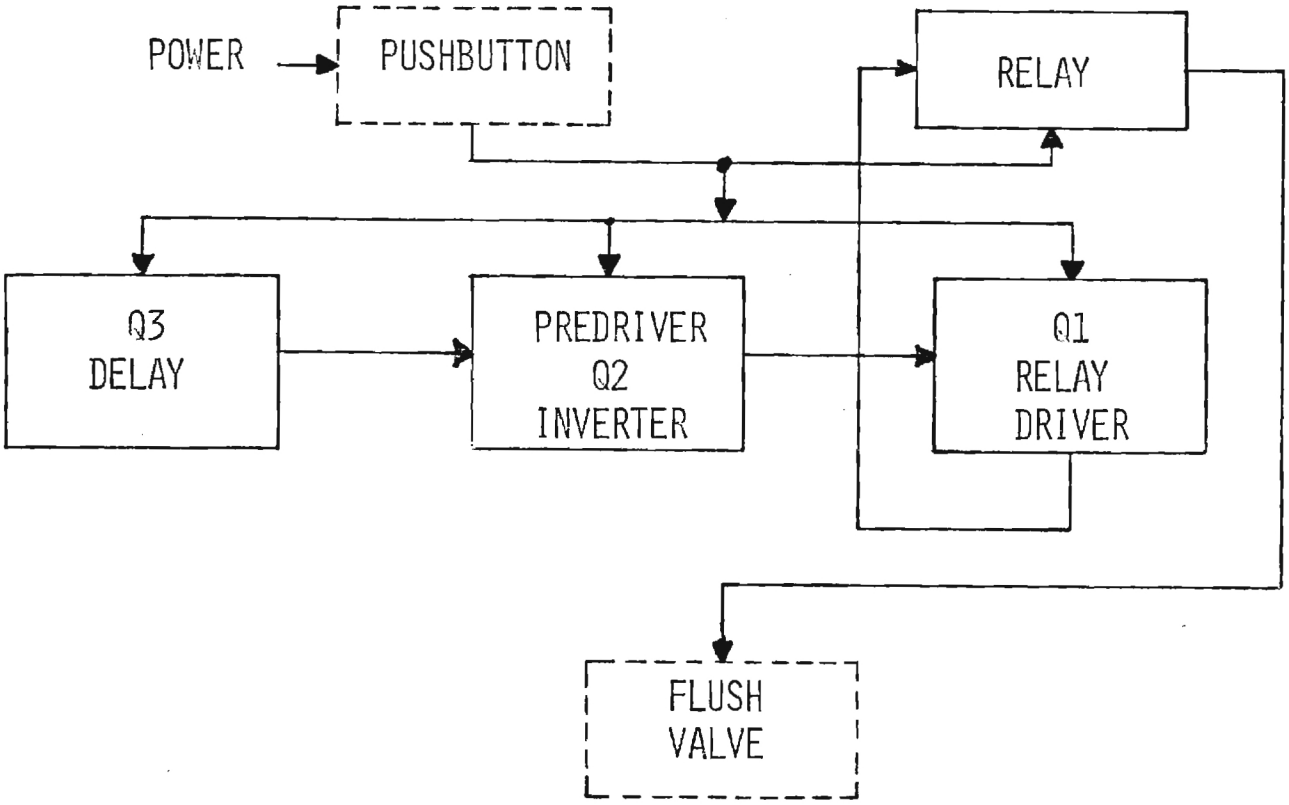

FIGURE 13. FUNCTIONAL BLOCK DIAGRAM P/N 103717

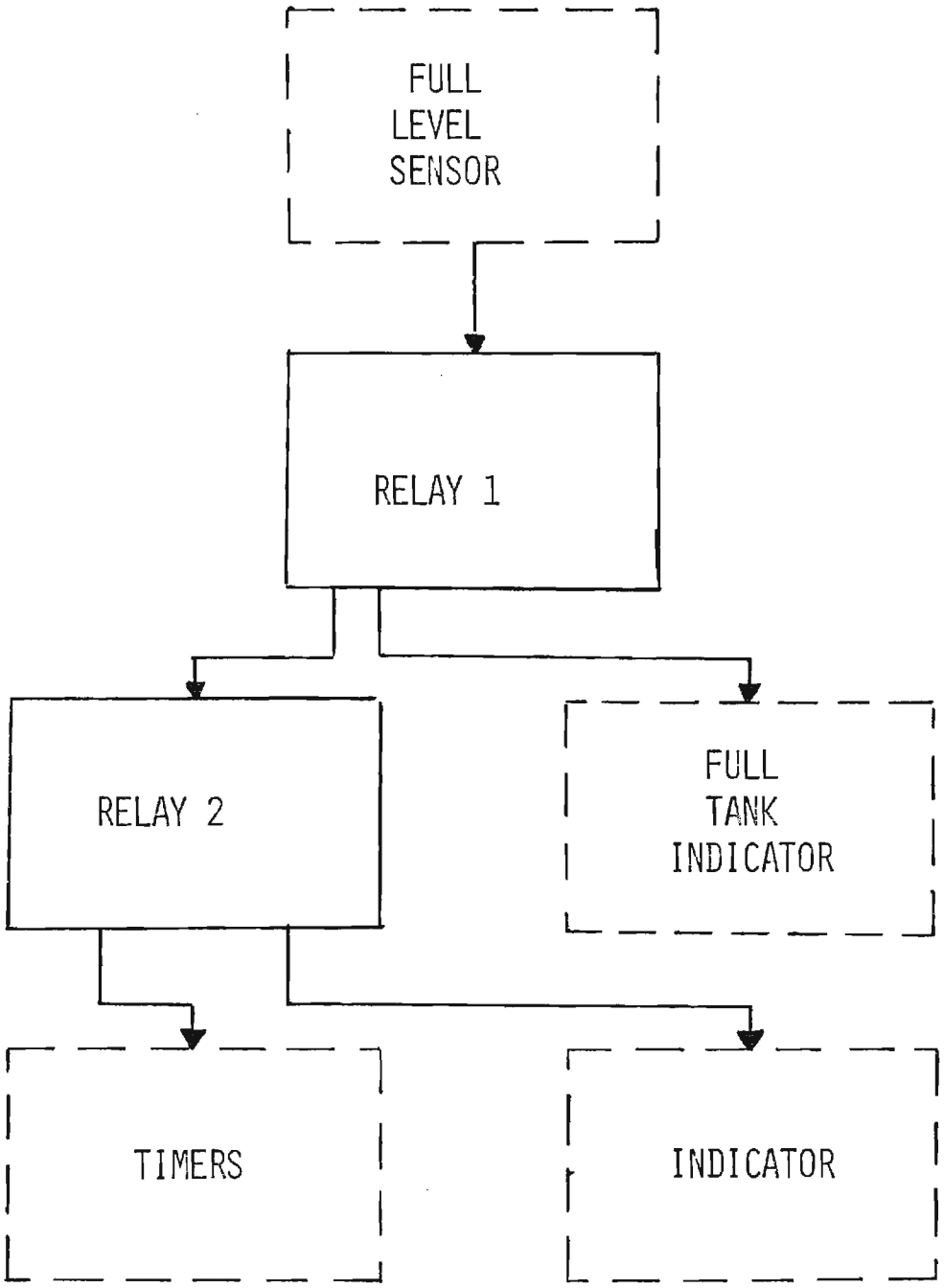

FIGURE 14. FUNCTIONAL BLOCK DIAGRAM P/N 103718

When pins 3 and 4 receive a 26 volt level transistor, Q2 turns on and relay 1 energizes providing 26 volts to pins 1 and 2. When pin 6 receives a 26 volt level transistor Q1 turns on allowing relay 2 to energize, if 26 volts is present on pins 3 and 4 (relay 2 will not energize unless relay 1 is in an energized state). When relay 2 energizes it provides 26 volts to pin 5 and opens the circuit to pin 2.

Resistors R2 nd R1 provide a voltage divider for Q1 and resistors R3 and R4 provide a voltage divider for Q2.

Diodes D3 and D4 conduct coil current to prevent damaging voltage kickbacks to the transistors. Diodes D1 and D6 provide emitter-base reverse bias protection and diodes D2 and D5 provide collector-base protection for transistors Q1 and Q2 respectively.

Presently there is no connection at pin 6, but applying 26 volts to pin 6 triggers an abort mechanism associated with transistor Q1 and relay 2 which deactivates the timing circuitry and prevents flushing, and provides 26 volts on pin 5 which is assumed to be an indicator of some sort.

IX. Proposed Improvements

There are two major deficiencies with the existing printed circuit cards in the Electronic Control Box for the Bare Base Chemical Toilet.

1. The printed circuit contacts used on the cards cost approximately $85 per board.

2. The existing circuit cards use out-dated design techniques to perform their logic and timing functions.

Using state-of-the-art electronic design techniques the 12-second timers (P/N 103717) and the logic control card (P/N 103718) could be reduced down to one circuit card. The new board could fit in the present Electronic Control Box in place of the existing motherboard. By so doing, the two deficiencies stated above would be alleviated.